Heat Waves

predictions over Europe at extended forecast range

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Motivation

Heat waves (HW) have high societal impact. The prediction of such an extreme event a few weeks in advance would be particularly useful. Since HW can last more than a week they could be the type of weather events that the sub-seasonal prediction systems can forecast. Hence we have started to evaluate the skill of ECMWF extended range ensemble in predicting HW.

Several studies have shown that HW over Europe during the warm season are related to persistent large-scale high pressure systems (Della Marta et al. 2007). Those systems are sometime associated with global teleconnections linked to tropical organized convection (MJO) (Cassou et al. 2005). Because of their low-frequency nature and their links to remote anomalies, they can exhibit predictability on the sub-seasonal time scale.

A further source of predictability arises from the effect of soil moisture conditions in the amplification of the temperature anomalies.

	Anticyclonic summer weather regimes (BL/AL)	Cyclonic summer weather regimes (AR/NAO-)
Dry Winter/Spring	Feedback amplification Many hot days	Feedback inhibited Few hot days
Wet Winter/Spring	No feedback possible Few hot days	

Figure 1: Schematic picture of the combined sensitivity of hot days to summer atmospheric circulation and soil moisture conditions (From Quesada et al. 2012)

Ensemble forecasting system

Since October 2004 ECMWF issues operationally an ensemble of forecasts covering 32 days ahead. A 51-membes ensemble is integrated for 32 days twice a week (Mondays and Thursdays at 00) using a coupled model.

(please refer to F. Vitart presentation Session D1 for further details on the ECMWF operational system)

www.ecmwf.int/research/monthly_forecasting/Documentation.html

Selection of Heat Wave events

HW events are identified by using an objective index that detects spatially coherent patterns of temperature anomalies persisting for some days.

Heat waves index:

For each grid-point the temperature has to exceed the upper 95th centile of the local climatological distribution and this condition has to persist for at least 4 days. The above conditions have to be valid for al least 60% of the neighbouring points located within a radius of 1.875 degree. (Stefanon et al. 2012)

We have used this index to identify 4 types of HW event in the era-interim data set for the summers 1979-2012. However the present study is limited to the HW events occurring during the 2005-2012 when the real-time ECMWF extended range forecasts are available.

During this period we have identified : 6 HW events over Eastern Europe (EE), 4 over Russia (RU), 3 over the Northern Sea (NS) and 2 over Western-Central Europe (WE).

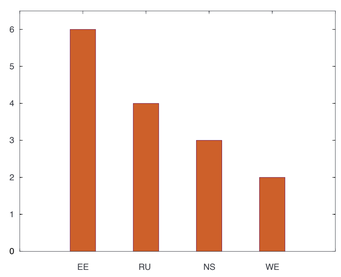

Figure 2: HW distribution during the summers 2005 to 2012

Heat waves composites from analysis

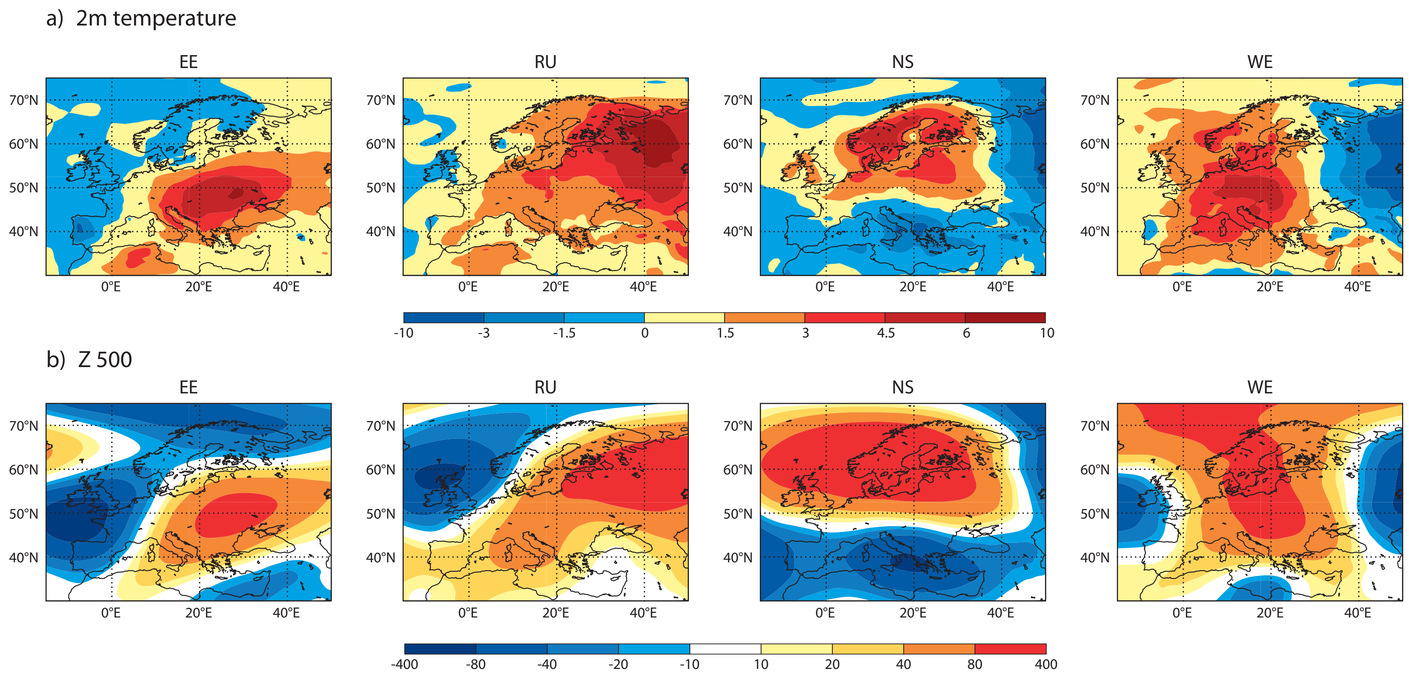

Figure 3: Composite maps from the analysis during EE , RU, NS and WE HW events. The EE events have their temperature maximum over Poland/Romania. The composite for the RU events includes the 2010 case with max temperature over Northern Russia. The NS composite show very warm condition over Scandinavia and UK. The WE composite anomaly has similar shape of the 2003 event although this is not included in the composite. The z500 composites show an anticyclonic anomaly in phase with the temperature anomaly.

Heat waves for the ensemble forecast at 12-18 day range

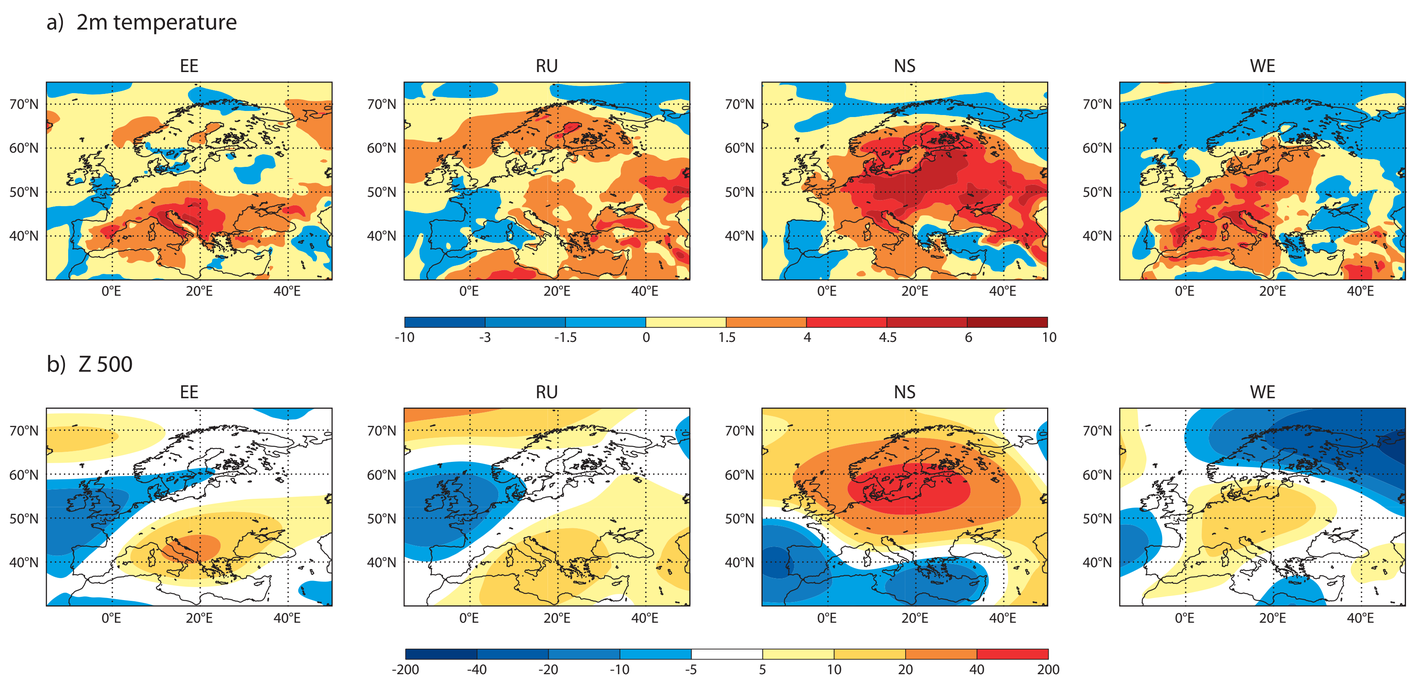

Figure 4: Composite maps from the ensembles forecast at 12-18 days verifying the composites in figure 3.

Summary

We have identified 15 HW events classified into 4 types. All the operational extended forecasts initiated around two weeks and three weeks before the onset of each event were assessed.

Objective verification of probability forecasts requires a far larger sample that is available. This is typically the case for any investigation of extreme events. Therefore the cases were investigated individually and we have used the composites from analysis and ensemble mean anomalies to summarize the results.

The forecasts for the EE events gave some indication of warm conditions although the location of the temperature anomalies was not accurate and generally displayed South. The WE event in 2006 was well predicted while the one in 2011 was reproduced with less accuracy. It is worth mentioning that the WE 2006 event exhibits much larger anomalies than its counterpart in 2011. Forecast gave accurate prediction for all the 3 HW events over the Northern sea which were all associated with a Scandinavian blocking. Although the Russian heat wave in 2010 was well predicted up to three weeks ahead the other 3 RU events were not reproduced.

Since 2004 the operational system has been upgraded several times and its skill has improved (Vitart 2014). It is possible that some of the HW events, not well predicted at that time, are better captured by the current system. We are running additional experiments to address this question.

Generally the successful predictions persisted the anti-cyclonic circulation which was already present at the initial conditions. In contrast most of the non-successful predictions did not have an anti-cyclonic circulation in the initial conditions. The skill in predicting heat waves at the extended range may therefore be limited by the ability of the forecast model to represent transitions to anti-cyclonic circulation regimes. We are going to evaluate the role of tropical forcing and initial soil moisture conditions in each events.

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